EVALUATION OF MARGINAL FIT OF METAL CERAMIC AND METAL FREE CERAMIC CROWNS- AN INVITRO STUDY

A Dissertation Submitted

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In partial fulfillment of the requirement for the degree of

MASTER OF DENTAL SURGERY
(BRANCH VI-PROSTHODONTICS)

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CERTIFICATE

This is to certify that the dissertation titled **“Evaluation Of Marginal Fit Of Metal Ceramic And Metal Free Ceramic Crowns- An Invitro Study”** is a bonafide record of work carried out by **Dr.V.PARIMALA** , during the period of 2006-2009. This dissertation is submitted in partial fulfillment, for the degree of Master of Dental Surgery awarded by Tamil Nadu Dr. MGR Medical University, Chennai in the branch of Prosthodontics. It has not been submitted partially or fully for the award of any other degree or diploma.

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DECLARATION

I **Dr.V.PARIMALA**, do hereby declare that the dissertation titled **"Evaluation of Marginal Fit of Metal Ceramic and Metal Free Ceramic Crowns- An Invitro Study"** was done in the Department of Prosthodontics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government dental college for the study in partial fulfillment of the requirements for the degree of **Master of Dental Surgery** in the speciality of **Prosthodontics (Branch VI)** during the course period **2006-2009** under the conceptualization and guidance of my dissertation guide**, Dr.A.Meenakshi, MDS.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG student Signature of the HOD

Signature of the Head of the Institution

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CONTENTS

INTRODUCTION

The smile is one of the most appealing aspects of the human face and is considered to be the very image of the soul. An esthetically pleasing appearance of teeth is the best asset for a good smile.

Ceramic restorations because of their natural translucency and tooth like color provide excellent esthetics and are virtually indistinguishable from the adjacent natural dentition. Full veneer ceramic crowns are very successful in this aspect because by covering the entire tooth they can totally mask the previous condition to create a new appearance.

Dr. Charles Land [37] introduced one of the earliest forms of ceramic crowns in 1903. Then the first metal-ceramic crown was described by Brecker [37] in 1956. Since then various types of metal ceramic restorations have been developed with advancements being made in both the type of the metal & the porcelain for an effective metal ceramic bond.

From its introduction till date, the porcelain fused metal restorations have a long proven record of success because of their good compressive strength, marginal fit, fracture resistance, & the versatility to be used for both single crowns and fixed partial dentures. But the esthetic limitations like lack of metal translucency, exposure of metal collar in the anterior region, paved way for all ceramic metal free restorations.

The absence of metal layer in the all ceramic restorations helps in transmission of light through the full depth of the restoration, thereby enhancing the translucency creating a life like appearance.

Mcleaan and Hughes [44] in 1965 introduced the first all ceramic porcelain jacket crowns made of high strength alumina core.

Heat pressed ceramics were introduced by Ivoclar in the 1990s [44]. Here a ceramic substructure (ceramic core) is made by pressing the ceramic ingots into a refractory mold made by the lost wax technique. These ceramic copings thus obtained can be finished to the final form either by a characterization technique, involving surface stain only, or by layering technique involving application of veneering porcelain.

Depending upon the clinical demand, both all ceramic and porcelain fused to metal can be used for full veneer crowns. The clinical success of a complete crown depends on many factors. It must seat accurately on the tooth, exhibit a minimum cement margin, be adequately retained and restore function & esthetics.

Of all these marginal fit is considered to be a primary and significant factor in the prevention of secondary caries, and is an important indicator of the overall acceptability and longevity of the restoration.

Clinically distortion of the margins creates a potential space between the crown and the tooth preparation. This space promotes leakage & dissolution of cement, encourages plaque deposition, initiates secondary caries, leads to gingival inflammation, periodontal disease, & finally results in deterioration of the restoration and the supporting tooth. So, the intimacy of fit of the crown margins is critical to ensure a smooth surface that will not promote accumulation of plaque.

Mclean & Von Fraunhofer [36] after examining more than 1000 crowns clinically over a period of 5 years showed that the clinically acceptable crown marginal discrepancies could range up to 120 µm after cementation.

The marginal fit of any restoration depends upon the inherent physical properties of the restorative material and also the way it is manipulated to get a good adaptation to the prepared tooth. For a ceramic crown with or without a metal substructure, most of the marginal discrepancies are induced in the fabrication stage because of multiple high temperature firing cycles used for porcelain application.

Ando et al [36] in 1972 reported that when a metal casting is subjected to degassing, there is a significant marginal discrepancy of about 100 - 150µm.

Other studies by various authors have identified many factors such as the type of the alloy, metal oxide formation on the fitting surface of the alloy, the thickness of the coping, mismatch of the porcelain-metal thermal contraction, porcelain firing shrinkage, release of casting induced stresses and several other factors as contributing to the distortion of metal ceramic crowns during fabrication. Regardless of the specific factor involved, the common denominator is the elevated temperature which definitely causes loss of the initial fit of the metal coping.[3, 7,14,15,21.]

Similarly in the fabrication of all-ceramic crowns made by application of veneering ceramic over a ceramic coping (layering technique), there is deformation of the ceramic substructure at repeated exposure to high temperatures. This has been proved in a study by Mehmet et al [48] on the marginal fit of 3 types of all-ceramic crowns.

Earlier studies have reported the marginal fit of all ceramic crowns to be inferior to that of the traditional metal ceramic crowns.

But of late, the heat pressed ceramic restorations provide a better marginal fit because of the leucite reinforcement in them which imparts more strength to the core ceramic, and also because of the technology of heat pressing the ceramic ingot which is more accurate than the earlier methods.

Edward et al [17] in 2005 studied the marginal fit of leucite glass pressable ceramic restorations and concluded that a pressed ceramic restoration has better marginal adaptation than a traditional metal ceramic restoration.

Hence this study was performed to analyze the marginal fit of heat pressed all ceramic crowns & metal ceramic crowns with the following aims &objectives.

The Aims Of The Study are

1. To evaluate the initial marginal fit of the metal copings made by induction casting with that of the ceramic copings made by heat pressing.

2. To evaluate the discrepancy in the marginal fit that has occurred after porcelain application in both the groups.

3. To compare the ultimate marginal fit of conventional metal ceramic crowns with that of heat pressed all ceramic crowns.

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REVIEW OF LITERATURE

Ideally cemented crown margins meet prepared tooth margins in perfect non detectable junctions. The definition of fit in the dental literature has been imprecise and various terms have been used to describe essentially identical measurements. The bulk of literature and research on complete crown margins falls into one of the 3 broad categories

1. Location of the margin
2. Configuration
3. Fit

Improper marginal fit clinically seen as an increased space between the tooth and the crown margin can be attributed to at least 2 separate sets of factors.

1. Distortion of margins of the restoration either during fabrication or during clinical use.

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2. In adequate seating of the crown over the tooth – this produces an increased marginal opening in

spite of having structurally good defect free margins.

The marginal fit of ceramic crowns is affected by both these factors.

Shillingburg et al. (1973)[36] published the results of facial margin opening changes of four different coping designs that resulted during porcelain firing & concluded that the greatest marginal opening occurred during those cycles in which porcelain was fired to Au-Pd-Ag copings. They also said that the shoulder margins had less marginal distortion than the chamfer margins

Feichtinger et al(1973)[36] - marginal distortion changes of upto 64µm were observed to occur during the metal oxidation treatment but not during the porcelain firing procedure

Iwashita et al(1977)[36] – studied the effect of full coverage porcelain & the partial veneer designs on fit of a metal ceramic crown. They found that the full coverage specimens showed the largest gap change of 187µm . Most of the marginal discrepancy occurred after the degassing procedure. The effect of thermal contraction differential between the metal & the porcelain was also found to be significant.

Kulmer et al. (1978)[36] demonstrated that gold alloy crowns which were heat-treated prior to porcelain firing cycles showed gap changes of less than 19 ulm. This finding suggests that porcelain-metal incompatibility stresses were not capable of producing metal distortion effects.

Robert R.Faucher et al (1980)[58]investigated the distortion in relation to the margin design in porcelain fused to metal restorations. They concluded that shoulder & shoulder with bevel designs exhibit significantly less marginal distortion than the chamfer margins and also said that the placing of additional metal at the gingival margin reinforces this margin and inhibits marginal distortion

Faucher and Nichols (1981)[36] monitored the change in the fit during a series of firing procedures. They said that after the porcelain firing cycles there was an increase in the mesiodistal dimensions and a decrease in the faciolingual dimensions. As reported by the previous authors they also concluded that most of the distortion occurred during the degassing cycle.

Buchanan et al(1981)[36] reported greater marginal discrepancy of the base metal alloys(70µm) when compared to that of the precious metals. The larger discrepancy of the base metal alloy was explained on the basis of the formation of oxide on the internal surface of these copings.

VanNortwick &gettleman et al(1981)[66] found statistically significant improvements in the fit of the castings by applying die-spacer. The amount of relief suggested is in the range of 20-40µm.

K.J.Anusavice et al (1984)[54] studied the effect of metal design on the marginal distortion of metal ceramic crowns and concluded that the calculated marginal distortions due to metal-porcelain thermal contraction mismatch depend primarily on the metal-porcelain combination and are insensitive to the coping design. They also confirmed that if the coping is kept in a minimal thickness of 0.1mm or less then they are more susceptible to localized or generalized distortion than a coping of higher thickness.

In yet another study by ***Anusavice et al in(1987)***[41] it was conclusively demonstrated that incompatibility stress induced by a positive contraction mismatch is not a primary cause of marginal or generalized distortion of metal-ceramic crowns and suggests that external grinding and internal abrasive blasting of crowns are more likely to cause this effect.

Richter- snapp et al in (1988)[42] – studied the effect of alloy type, margin design and porcelain proximity on the marginal fit of metal ceramic crowns and concluded that none of these factors or a combination of these affected the final fit of the restoration. Rather the only factor which could influence was the exposure to increased temperature.

It was ***Homes et al in (1989***)[30] who comprehensively discussed the description of crown fit. He established measurements of both internal fit & marginal fit and concluded that the best method was to determine the absolute marginal discrepancy. This was simply described as the distance from the margin of the casting to the cavosurface angles of the tooth preparation. Homes et al stated that this distance would always be the largest measurement of error at the margin and reflect the total crown misfit at that point both vertical & horizontal.

As mentioned earlier apart from structurally good margins the complete seating of the crown is essential for a good fit. The methods for measuring the marginal fidelity includes four different categories

1. Direct view
2. Cross-sectional method
3. Impression technique
4. Explorer &visual examination.

John A.Sorensen etal (1990)[35] compared & scrutinized the various methods used to measure the crown margin fidelity and claimed that the cross-sectional method of evaluation of margins allows greater precision in determination of the measuring points and also in measuring the absolute marginal fit. The authors claimed this method to be more advantageous than the other methods because sectioning favors a more reliable view of the actual surface of the marginal gap and in addition provides consistent reproducible &standardized points of measurement.

Farhad et al (1991)[22] compared the marginal fit of all ceramic crowns with metal ceramic crowns [renaissance crowns vs metal ceramic & dicor crowns]. This study concluded that Dicor & metal ceramic crowns fit better than the renaissance crowns.

Tam S.Hager et al (1993)[69] studied the effect of selective die spacer placement techniques on the seatability of the castings. The results of this study pointed out the need for providing additional relief at the axial walls when casting base metal alloys. This was because of the casting shrinkage resulting in tight fitting crowns binding along the axial walls more frequently than in other areas. So an additional layer of die spacer has to be applied to these areas for better seating of the crown.

Stephen D .Campbell et al (1995)[68] studied the effects of firing cycle and surface finishing on the distortion of metal ceramic castings and reported that thermocycling of metal ceramic restorations resulted in increased marginal openings and also that all of the loss of marginal fit occurred during the first thermocycling of the alloy.A fourfold statistically significant improvement ($p \leq 0.001$) in the marginal adaptation of a metal ceramic restoration was observed when the initial thermal cycle was completed before the specimens were finished.

Deniz Gemalmaz et al in (1995)[15] analysed the marginal fit changes that occur during the porcelain firing cycles of palladium – copper and nickel chromium copings and concluded that a greater change in the marginal fit occurred after the degassing stage and after the firing of body porcelain. Palladium copper copings showed more marginal discrepancy (19.39µm) than nickel chromium copings(8.65µm).

Christian Lehner et al (1997)[10] did a short term [2 years] clinical evaluation of the heat pressed IPS-Empress crowns and reported that 79.5% of the crowns were rated excellent from the clinical & functional standpoint. The marginal adaptation of the crowns was good with high degree of patient satisfaction

Kenneth et al (1998)[43] measured of fit of the Procera all ceram crowns fabricated with Procera CAD/CAM technology and concluded that the marginal fit of these crowns were below 70µm which is conductive to clinical success.

Titanium alloys are important for dental implants and are recently being developed as an alternative alloy for metal ceramic restorations. This is because of the unique physical characteristics of titanium alloys such as biocompatibility, high modulus of elasticity, low mass, high mechanical strength & resistance to corrosion.But there are some difficulties because of the casting difficulties of titanium and also because the thick oxide layer interferes with the ceramic bonding

Morakot Piemjai et al (2001)[51] evaluated the effect of seating force , margin design, cement on marginal seal, and retention of complete metal crowns. These authors said that there was a significant difference in the marginal seating ($P<.05$) between the different seating forces , for marginal design, with 2 different luting cements. Increasing the seating force from25 to 300N significantly improved the seating of the complete metal crowns with chamfer, shoulder &shoulder with bevel margins.

Efstratios Papazoglou et al (2001)[18] evaluated the distortion of high palladium metal ceramic crowns during ceramic firing at 4 stages- the as cast fit , after oxidation , after 2 simulated opaque porcelain firings, and after 2 simulated dentin porcelain firings. The results of this study suggested that most high palladium alloys exhibited minimal distortion that would not produce clinical problems. This is because the high palladium alloys have excellent resistance to creep at low stress & high temperature conditions.

M.J.Cattell et al in (2001)[45] analysed the flexural strength optimization of a leucite reinforced glass ceramic.. The study showed concluded that the fine leucite crystal size and the uniformity of microstructure caused by the dispersion of the leucite crystals during heat pressing is associated with significant increase in the biaxial flexural strength and reliability of the core ceramic. Such leucite reinforced ceramics have distinct advantages & are very useful in the fabrication of durable & esthetic heat pressed dental restorations.

Michael behr et al (2003)[49] did an in-vitro study to investigate the marginal adaptation and fracture resistance of heat pressed glass ceramic and fiber reinforced composite molar crowns with 3 types of cements. They found that both the restorations had highest fracture resistance & better marginal adaptation if they were luted with resin cement.

Stefan Wolfart et al (2003)[67] did a clinical evaluation of the marginal fit of heat pressed all ceramic crowns before and after cementation and found that adhesive cementation caused a significant increase of the marginal discrepancy of a full crown. This was because a full crown has a larger surface area on the occlusal surface. So more cement gets trapped on the occlusal surface. In addition the steeper axial walls prevent the easy outflow of the cement as the crown is seated. All these factors increase the hydraulic pressure on the resin cement thus preventing its complete seating.

Xin –Hua Gu et al (2003)[72] evaluated the marginal discrepancies and leakage of all-ceramic crowns cemented with different luting agents after fatigue tests. They reported that the marginal discrepancies of the all-ceramic crowns cemented with 3 different luting agents were smaller than that of the metal ceramic crowns. This result is mainly attributed to the excellent adaptation properties of the heat pressed ceramics. They also concluded that the adhesive composite resin luting system Panavia minimized the marginal leakage of all ceramic crowns and was far superior to zinc phosphate and compomer luting cements.

Massimiliano Guazzato et al (2004)[47] evaluated the strength ,reliability and mode of fracture of bilayered porcelain/core ceramics and concluded that in bilayered ceramics the strength and reliability were improved by the core material that possessed better mechanical properties.

Mehmet et al (2005)[48] studied the influence of firing cycles on the marginal distortion of 3 different all-ceramic systems- In-ceram, copy milled in-ceram &copy milled feldspathic crowns. Of these the copy milled feldspathic crowns showed the least marginal discrepancy (17±12μm), because the milled crowns are subjected to glaze firing only. Whereas in-ceram crowns and copy milled in-ceram crowns showed significant marginal distortion (57±24µm, 57±32µmrespectively) because of the repeated high temperature firing cycles during porcelain build up.

Edward B. Goldin et al (2005)[17] compared the marginal fit of leucite –glass pressable ceramic restorations and ceramic pressed to metal restorations with a traditional metal ceramic crown. They concluded that a pressed ceramic restoration [81±25µm] with or without a metal has equal or better marginal adaptation than a traditional metal ceramic restoration[94±41µm].

Giuseppe Isgro et al (2005)[24] evaluated the influence of multiple firing on the thermal contraction of ceramic materials used for the fabrication of layered all- ceramic restorations. It was concluded that glass-ceramics and aluminous porcelain exhibited more stable thermal behavior after repeated firing. So the fabrication of a layered all- ceramic restoration , using these materials , could be more reliable.

Niek De Jager et al (2005)[53] studied the influence of the stresses caused by the veneering porcelain on the dental core ceramic by finite element analysis. The study concluded that though the ceramic cores were sufficiently strong to produce long lasting restorations, the stresses in the veneering porcelain can reduce the longevity. At the core veneer interface, the maximum tensile stress is higher for crowns with ceramic cores. So they suggested that the bonding between veneering porcelain and these strong ceramic cores should be improved to exploit fully the strength of these materials.

Jianxiang Tao et al (2006)[33] analyzed the fit of metal ceramic crowns cast in Au-1.6wt%Ti alloy for different finish line curvature and concluded that these titanium alloys had accuracy of marginal fit as good as that of gold alloy. After porcelain application, there was a larger labial marginal gap corresponding to the finish line curvature.

Carla Castiglia et al (2008)[9] did an elaborate study to analyze the mechanical properties & porosity of 2 commercial glass ceramics – [leucite reinforced & lithium di silicate reinforced] after hot pressing them at different temperatures. They concluded that the microstructure of leucite reinforced ceramic was not affected by the different amounts of energy provided during the hot press technique, leading to similar mechanical properties in different temperatures. This is because these ingots were already subjected to heat treatment between 920 - 1200°c by the manufacturer which causes the leucite crystal growth dendritically from the nucleating centers in the base glass. So when the ingots are heated again during the firing procedure, the leucite crystals undergo a maturing process resulting in a more homogeneous distribution throughout the glassy matrix. Because of this the leucite reinforced glass ceramics have good mechanical properties, low porosity & good marginal fit .

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MATERIALS AND METHODS

This invitro study was performed to evaluate the accurate marginal fit of the metal ceramic and pressed ceramic jacket crowns over the prepared tooth. This study also involved to evaluate the distortion of metal and ceramic copings due to repeated heating during the processing procedure.

A typhodont maxillary right central incisor was prepared for a jacket crown. A uniform labial nd axial reduction of 1.5 mm was made along with a 2mm incisal reduction and .an uniform shoulder of 1.5mm. The height of the preparation was 7mm with a convergence angle of 6°.

Before starting the preparation the index of the unprepared tooth was made with putty silicone to facilitate the accurate reduction of the tooth. The occlusal and axial reductions of the teeth were carried out using this putty index.

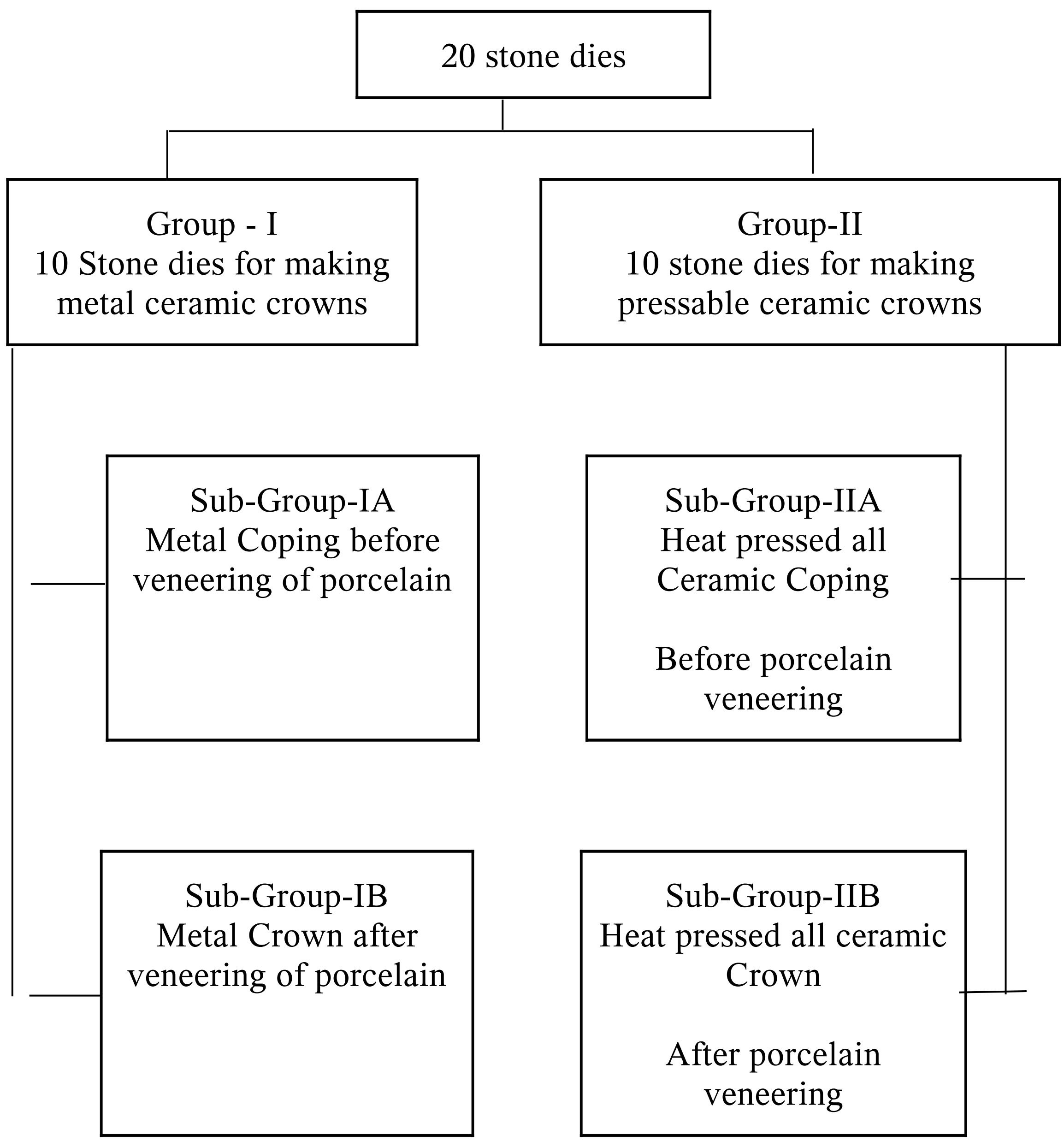
20 impressions of the prepared tooth were made in light body poiy vinyl siloxane impression material by using individualized custom made impression trays. The impressions were cast on die stone.

The 20 stone dies were then divided into 2 groups as Group I and II.

Group I - consists of 10 stone dies for the fabrication of metal ceramic crowns

Group II- consists of 10 stone dies for the fabrication of Pressable ceramic crowns

FLOW CHART



MATERIALS USED IN THIS STUDY

Sl no	Material	Manfacture name
1.	Die stone	zerhmark
2.	Bellavest	Beggo, germany
3.	Addition silicone	Ivocloar,
4.	Inlay wax	GC coporation
5.	Ceramic ingots & veneering ceramic	Cergo dentsply

EQUIPMENTS USED IN THIS STUDY

Sl no	Equipments used	Manfacture name
1.	Casting machine	Fornax, beggo Germany
2.	Ceramic furnance	Mulitmat two touch and press, Dentsply
3.	Vaccum Mixer	Beggo, Germany
4.	Sectioning machine	Brain-cut–UM,Metco Pvt Ltd

I. FABRICATION OF METAL COPINGS

Application of die spacer

First the preparation margin on the die was defined and dies hardener applied. 3 layers of paint on die spacer producing a thickness of approximately 33-40µm was applied 1mm short of the margins.

Preparation of wax pattern

The wax patterns were prepared using inlay casting wax to an uniform thickness of 0.5mm. The dimensions were confirmed by measuring at multiple points with a wax thickness caliper.[25,58] [± 0.1 mm]

Investing

The wax patterns were coated with debubblizer and invested in phosphate - bonded investment, strictly adhering to the manufacturer's instructions.

Burn out

The invested rings were placed in the preheating furnace and heated from room temperature at 30°F/minute to a maximum temperature of 1500°F {815°C} and then held at this temperature for 30 minutes.

Casting

Casting was done in an induction casting machine and the nickel chromium alloy was used for this purpose. A total of 10 metal copings were cast in the similar fashion. The copings vere then retrieved cleaned and inspected for any visible flaws. Those with gross defects were rejected and new ones made. Small nodules that might prevent complete seating of the coping were removed with a round bur at slow speed. After final trimming, the thickness of the coping was confirmed with a metal thickness caliper at multiple locations, the copings were then seated on their respective dies.

II. FABRICATION OF PRESSABLE CERAMIC COPINGS

Application of die spacer

First the preparation margin o the die is defined and die hardener applied, two layers of die spacer is applied 1mm short of the margins to get a thickness of approximately 30-40μm.

Wax pattern

The wax patterns were made by using inlay casting wax intended for pressable ceramic work, to a uniform thickness of 0.7 mm as recommended by the manufacturer. All the wax pattern dimensions were confirmed with a wax thickness caliper [± 0.1 mm]

Investing

The wax patterns were sprued in such a way that both the pattern and the sprue lie on the same line vertically, to facilitate same direction of flow of ceramic.

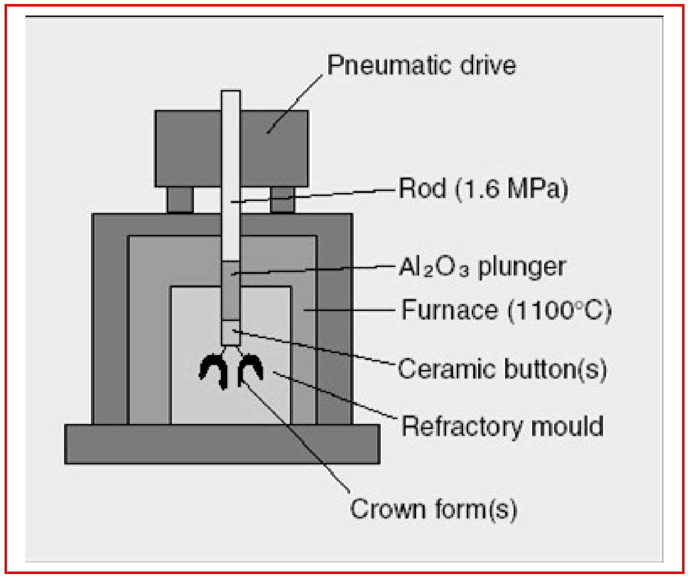
The patterns were immediately invested in phosphate bonded investment, strictly adhering to the manufacturers instructions.

Burn out

The mould is heated from room temperature to 800°C.

PRESSING

It is then taken from the furnace and a pellet of pressable ceramic [cergo, dentsply] is placed in the mould. The aluminium oxide plunger is placed over the ceramic pellet. The mould with the pellet and the plunger is immediately placed in the press furnace [MULTIMAT TOUCH AND PRESS] and the press progame is started. It takes 45 minutes for the press procedures to be complete and the temperature reaches a maximum of 960°C. The ingot is pressed into the mould at 960°C with a holding time of 20 minutes. Then the mold is left to cool at room temperature. The copings were carefully divested, cleaned and sprues were cut with fine diamond discs using water cooling without applying pressure. A total of 10 ceramic copings were made in the similar fashion.



III. MEASUREMENT OF INITIAL MARGINAL FIT OF THE COPINGS:

The copings were then seated on their respective dies with finger pressure and the marginal fit was measured using the video measuring system. This is to ensure that the copings had a good initial fit before application of porcelain.The measurementa were made at the following 6 points around the circumference of the crown.

1 point- mid facially

1 point — midpalatally

2 points — on the mesial side

2 points — on the distal side

The mean of all the 6 values measured is the initial marginal fit of the coping. The measurement sites were maked for reproducible identification by scoring the die with a sharp blade. Care was taken not to contact the marginal areas.[48]

The copings are now ready for porcelain build up.

IV. PORCELAIN BUILD UP ON THE METAL COPING BY LAYERING

The following schedule was followed for application of porcelain by layering technique.

Degassing -by placing the coping directly at 1200° F (650°C) and the elevating the temperature at the rate of 15°F (31ºC) per minute. Final temperature of 1925°F (1050°C) is reached- for 15 minutes. After degassing the copings were cooled in open air.

Opaque porcelain-applied to a thickness of 0.5mm and condensed by vibration

Dried by placing them on firing tray on a hot plate 700°F (370°C) 20 minutes	→	Transferred to the furnace already preheated to 1200°F (650°C)	→	Maximum temperature 1750°F (950°C) in partial vaccum (720mm/Hg.

A correction bake using identical procedures was performed to attain a baked thickness of 0.3mm

Body and incisal porcelain — added to make contours of all specimens as uniform as possible

Dried by placing them on firing tray on a hot plate 700°F (370°C) 20 minutes → Transferred to the furnace already preheated to 1200°F (650°C) → Maximum temperature 1750°F (950°C) in partial vaccum (720mm/Hg.

After reaching 1750°F the vaccum was released and the copings were allowed to air fire an additional 1 minute at 1750°F (950°C). A patch bake of either body or incisal porcelain or both was accomplished using the same procedures.

Before glazing the margins were carefully finished to the proper contours with a rubber wheel.

Glazing

Preheated to 700°F (3 70°C) → Transferred to the furnace already preheated to 1200°F (650°C) → Maximum temperature 1800°F (980°C) atmospheric pressure for 3 mm.

A total of 10 metal ceramic crowns of uniform contour were made.

PORCELAIN BUILD UP - ON THE CERAMIC COPING BY LAYERING TECHNIQUE

Firing programmes

	Pre heating °C	*Vaccum hpa*	*Firing temp*	*Time min*
1st Dentine firing	450°C	50	800°C	1 min
2nd Dentine firing	450°C	50	800°C	1 min
Glaze firing	450°C	–	790°C	1 min

A total of 10 heat pressed all ceramic crowns of uniform contour was made.

III. SECTIONING OF THE FINAL SAMPLES

The crowns were cemented to the respective dies with $ZnPO_4$ cement using finger pressure. The crown die complexes were then embedded in rectangular acrylic block. The samples were then sectioned faciolingually and mesiodistally with a diamond sectioning saw, following the guide marks on the dies. There are 2 interfaces for each point of sectioning so measurements can be made at 8 points around the crown. Mean vertical and horizontal marginal discrepancies were calculated, from the values obtained.[35]

Photographs

PREPARED TOOTH

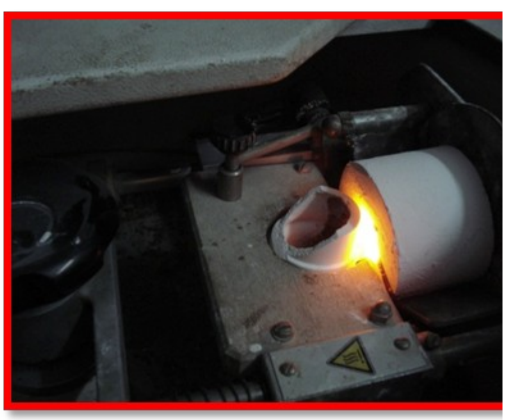
STONE DIE

10 STONE DIES FOR ONE GROUP

WAX PATTERN FOR METAL COPING

INVESTING

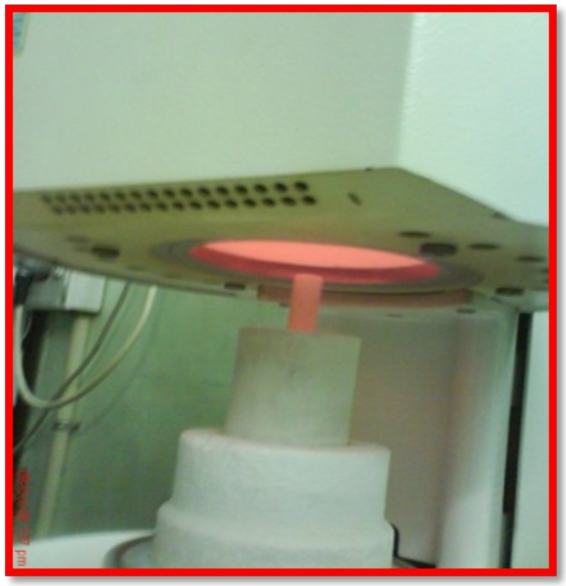
INDUCTION CASTING



METAL COPING

WAXPATTERN FOR PRESSED CERAMIC COPING & INVESTING

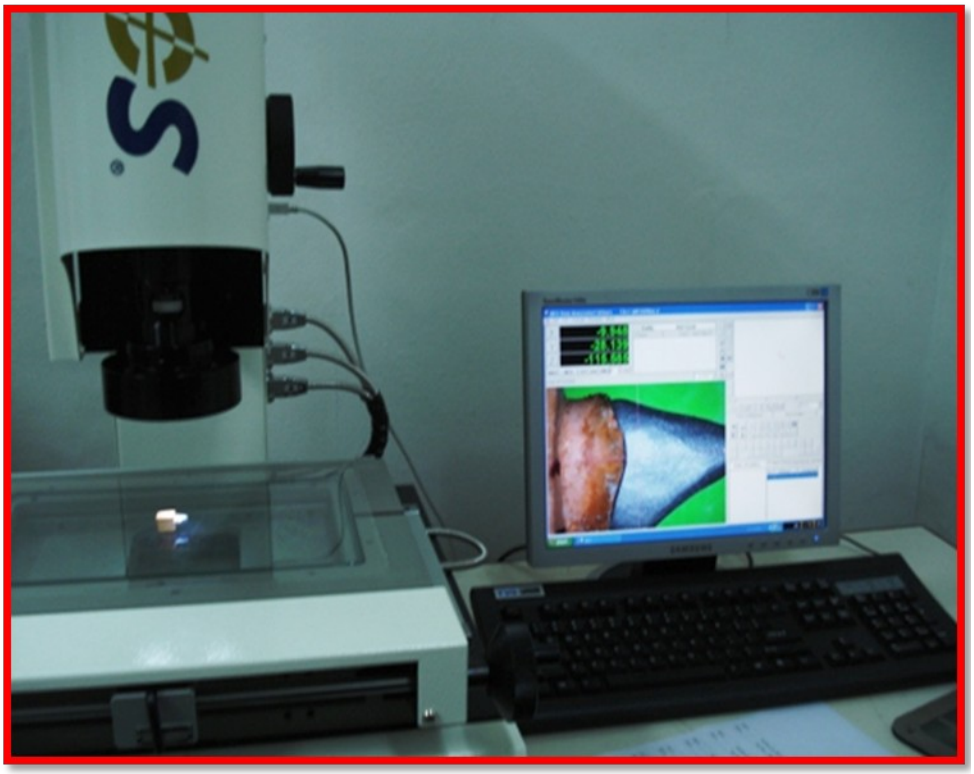
PRESSING OF CERAMIC INGOT



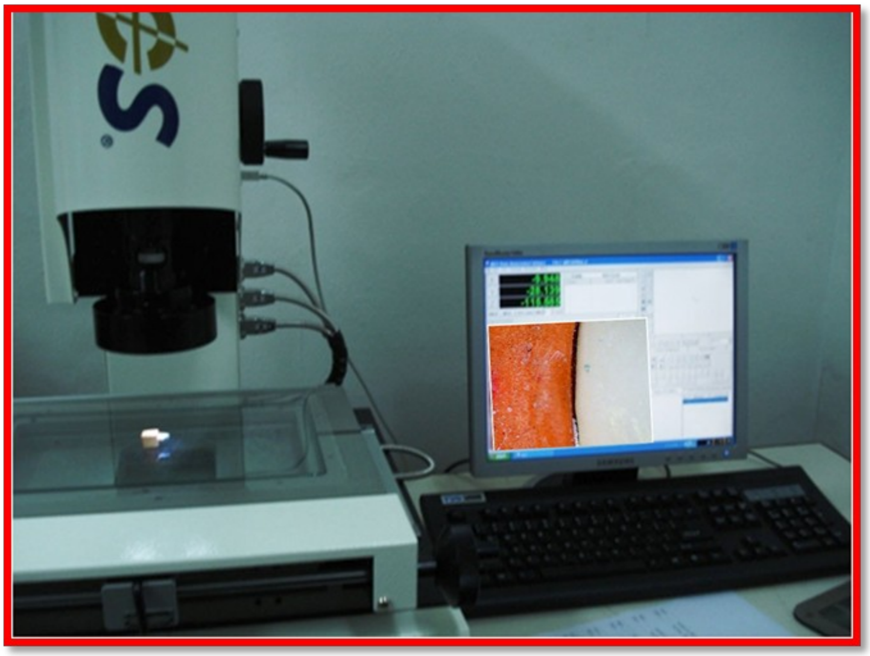
FINISHED CERAMIC COPINGS

RETRIEVED COPINGS

VIDEO MEASUREMENT SYSTEM-
ASSESING INTIAL MARGINAL FIT OF METAL COPINGS



VIDEO MEASUREMENT SYSTEM-
ASSESING INTIAL MARGINAL FIT OF PRESSED CERAMIC COPINGS



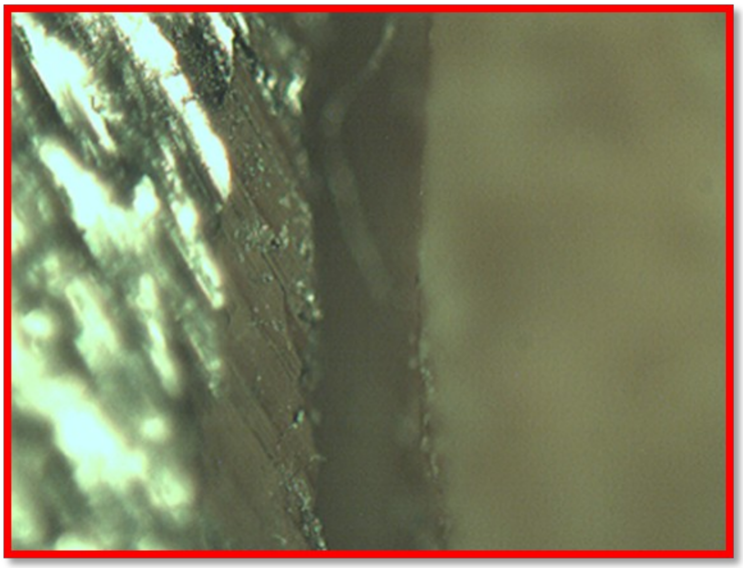
SECTIONING OF SAMPLES

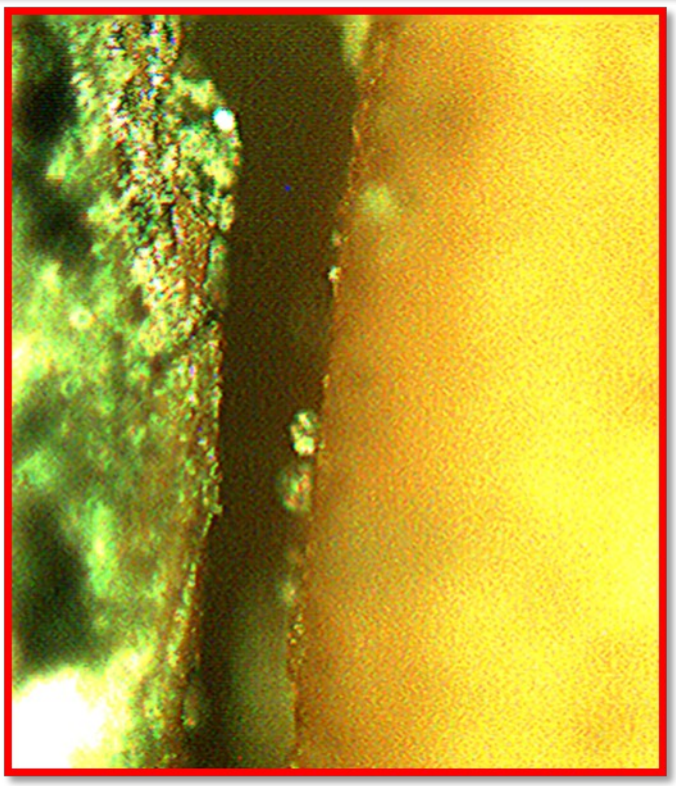
BRAIN CUT-UM THIN SECTIONING MACHINE

SECTIONED PRESSED CERAMIC SAMPLE

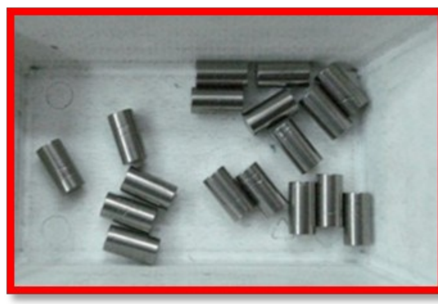
SECTIONED METAL CERAMIC SAMPLE

Sectioned samples at 100x magnification





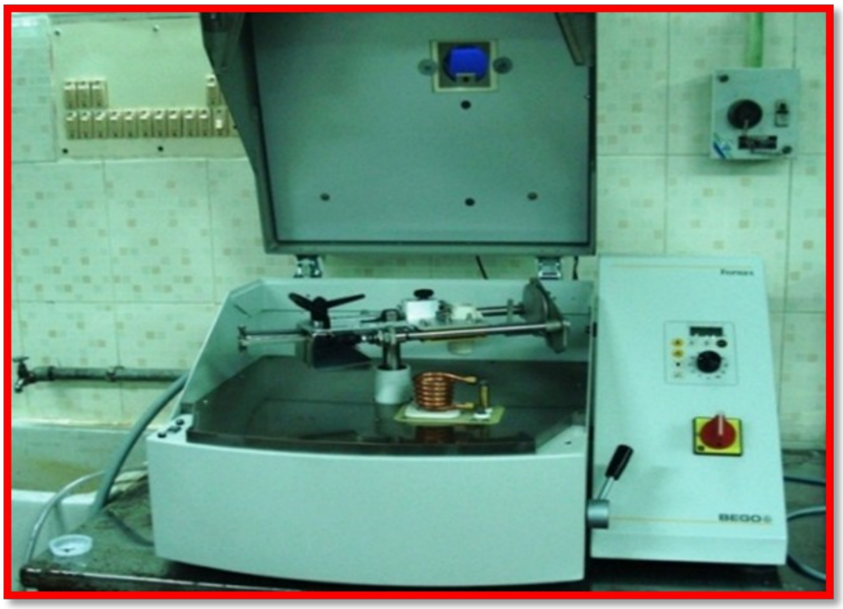
MATERIALS USED IN THIS STUDY



EQUIPMENTS USED IN THE STUDY

MULTIMAT 2 TOUCH &PRESS FURNACE

VACCUM MIXER



INDUCTION CASTING MACHINNE

MUFFLE FURNACE

RESULTS

This in vitro study was performed to analyze the marginal fit of metal and metal free ceramic jacket crowns and also to compare the amount of distortion that had occurred during the high temperature firing cycles during porcelain veneering.

The test samples were divided into 2 major groups based on the type of copings used for the jacket crown.

Group I - metal coping – for metal ceramic crowns

Group II - heat pressed ceramic coping – for all ceramic crowns

They were further subdivided into 2 subgroups each based on the stage of processing as , before and after veneering of porcelain.

Accordingly,

Sub group IA - metal coping before veneering of porcelain

Sub group IIA - ceramic coping before veneering of porcelain

1. The marginal fit of these copings were verified by measuring at 6 points around the circumference of the crown. The mean of all the 6 points was taken as the initial reading of marginal fit, before veneering of porcelain.

The same copings were then veneered with porcelain to the desired contour. The veneering porcelain was added incrementally in layers [layering technique] thereby subjecting the coping to multiple high temperatures firing cycles. The completed crowns were cemented on their respective dies using $ZnPO_4$ cement in the correct consistency. These are the final samples & they were considered as

Subgroup I B - metal ceramic crown after veneering of porcelain

Subgroup II B - all ceramic crowns after veneering of porcelain

The marginal fit of these final samples were assessed by the cross-sectional method. The samples were mounted in acrylic blocks and then sectioned faciolingually and mesiodistally following the markings on the dies. This creates 8 points of measurements around the circumference of the crown. The mean of all the 8 values was taken as the final marginal fit of the samples.

The means and standard deviations were calculated for all the samples and the results were statistically analyzed using analysis of variance test] ANOVA] among the groups and also within the groups.

Table .1- Mean values, standard deviations, and the results of one way ANOVA between subgroup IA and subgroup IIA

Metal coping before veneering [SUBGROUP-IA]	Pressed ceramic coping before veneering [SUBGROUP-IIA]	P VALUE
MEAN ± S.D	MEAN ± S.D	.00001***
51.34 ± 3.46	45.65 ± 4.27	

*** denotes significant at1 % level.

Table .2 - Mean values, standard deviations, and the results of one way ANOVA between subgroup IA and subgroup IB

Metal coping before veneering [SUBGROUP-IA]	Metal ceramic coping after veneering [SUBGROUP-IB]	P VALUE
MEAN ± S.D	MEAN ± S.D	.00003***
51.34 ± 3.46	79.15 ± 3.07	

*** denotes significant at1 % level

Table .3 - Mean values, standard deviations, and the results of one way ANOVA between subgroup IIA and subgroup IIB

Pressed ceramic coping before veneering. [Sub group IIA]	Pressed ceramic crown after veneering [SUBGROUP-IIB]	P VALUE
MEAN ± S.D	MEAN ± S.D	.0000I***
45.65 ± 4.27	67.97± 3.34	

*** denotes significant at1 % level

Table 4 - Mean values, standard deviations, and the results of one way ANOVA between subgroup IB and subgroup IIB

Metal ceramic crown after veneering [SUBGROUP-IB]	Pressed ceramic crown after veneering [SUBGROUP-IIB]	P VALUE
MEAN ± S.D	MEAN ± S.D	.00002***
79.15 ± 3.07	67.97± 3.34	

*** denotes significant at1 % level

INTERPRETATION OF RESULTS

Table 1.

It can be observed that the samples in subgroup II A have lesser values of marginal fit [45.6µm] than the samples in subgroup IA [51.2 µm] . This1difference is significant at 1% level.

This implies that the pressed copings had a better marginal fit than the metal copings.

Table 2

It can be seen that the samples in subgroup IB [79.32 µm] have marginal fit values higher than that of the samples in subgroup IA [51.2 µm] .The difference is significant by 1% level.

This implies that there was an increase in the marginal opening of the metal ceramic copings after veneering with porcelain.

Table 3

It can be observed that the samples in subgroup IIB have higher values of marginal fit [68.21 µm] than that of the samples in [subgroup IIA] [45.6 µm]. The difference is significant by 1% level.

This indicates that there was an increase in the marginal fit of the pressed ceramic copings after veneering of porcelain. But the amount of distortion was less than that observed for the metal copings.

Table 4

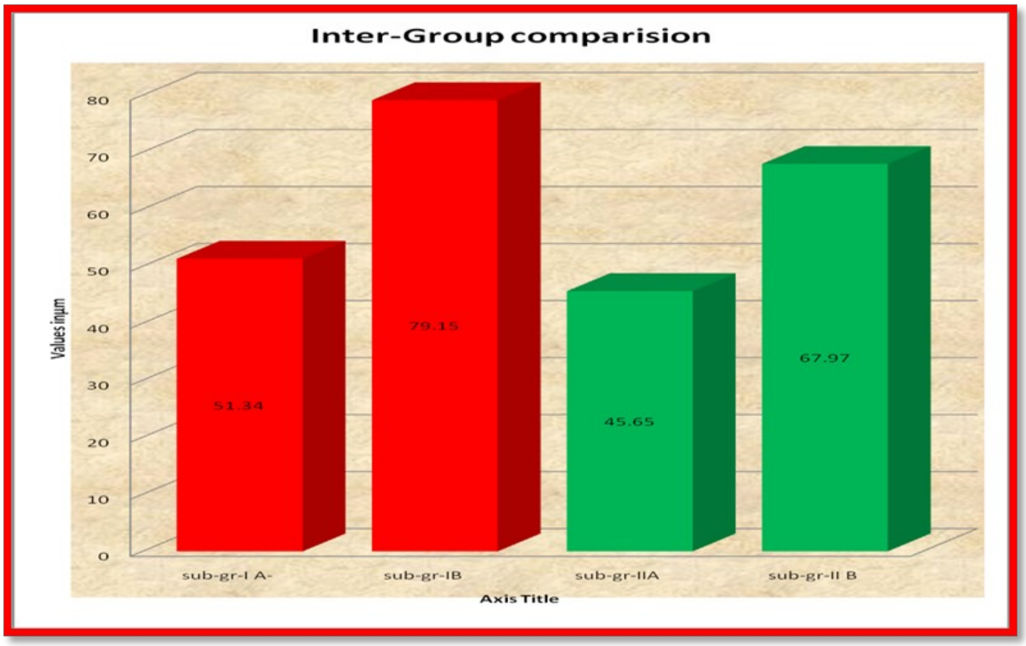
The values indicate that the samples of subgroup II B had lower values [68.21µm] of marginal fit than the samples of subgroup I B [79.32. µm]. The difference is significant by 1% level

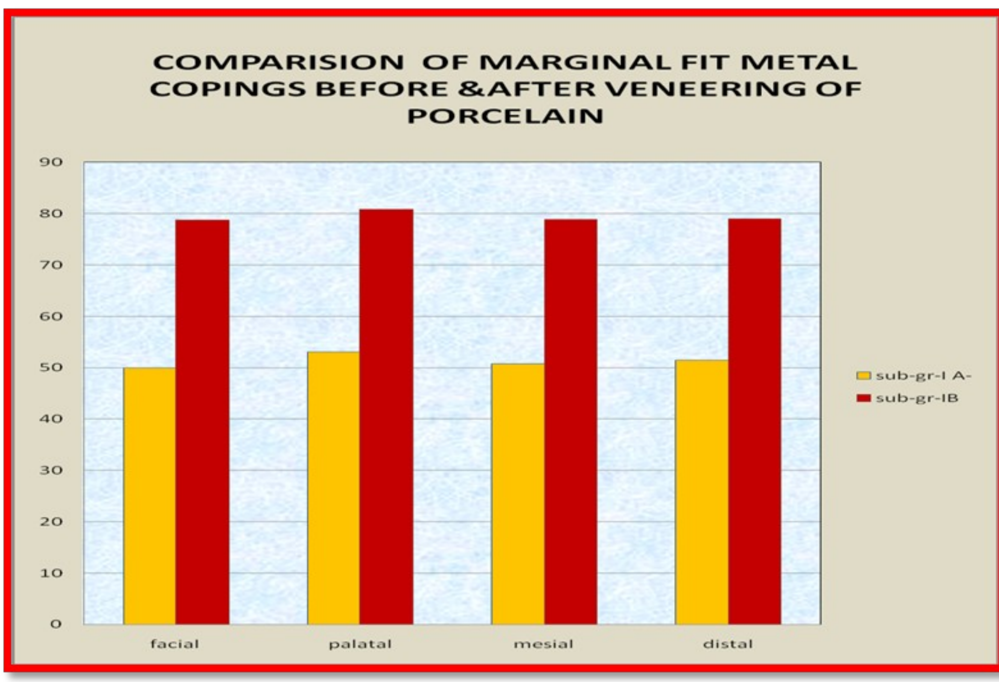
This implies that the pressed ceramic crowns had a better marginal fit than that of the metal ceramic crowns.

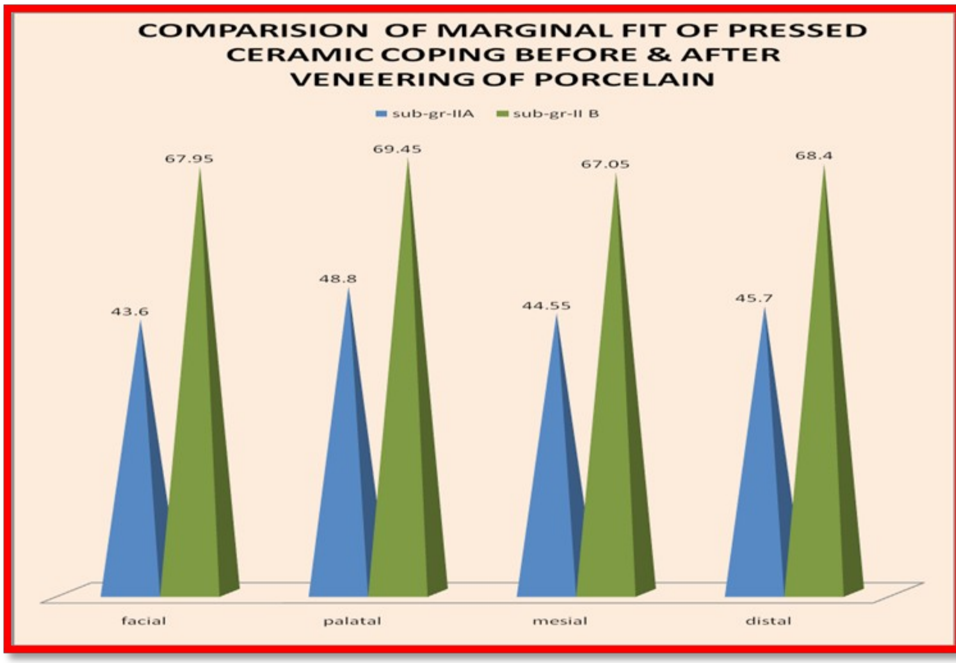
Table 5

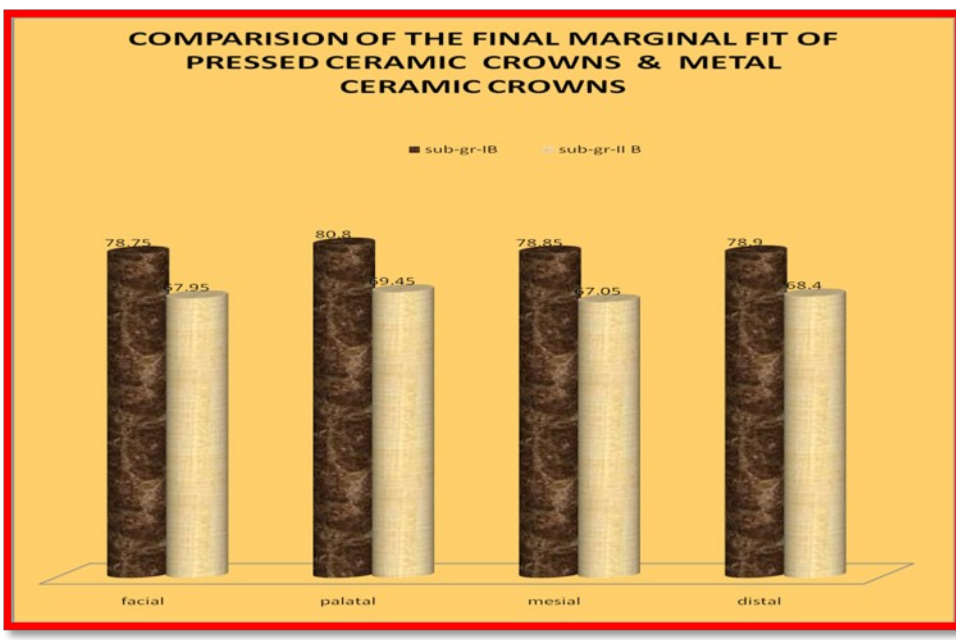
P value is insignificant, when the marginal fit values were compared among the different locations between the groups. This means that all the crowns had an overall uniform marginal fit around the entire circumference.

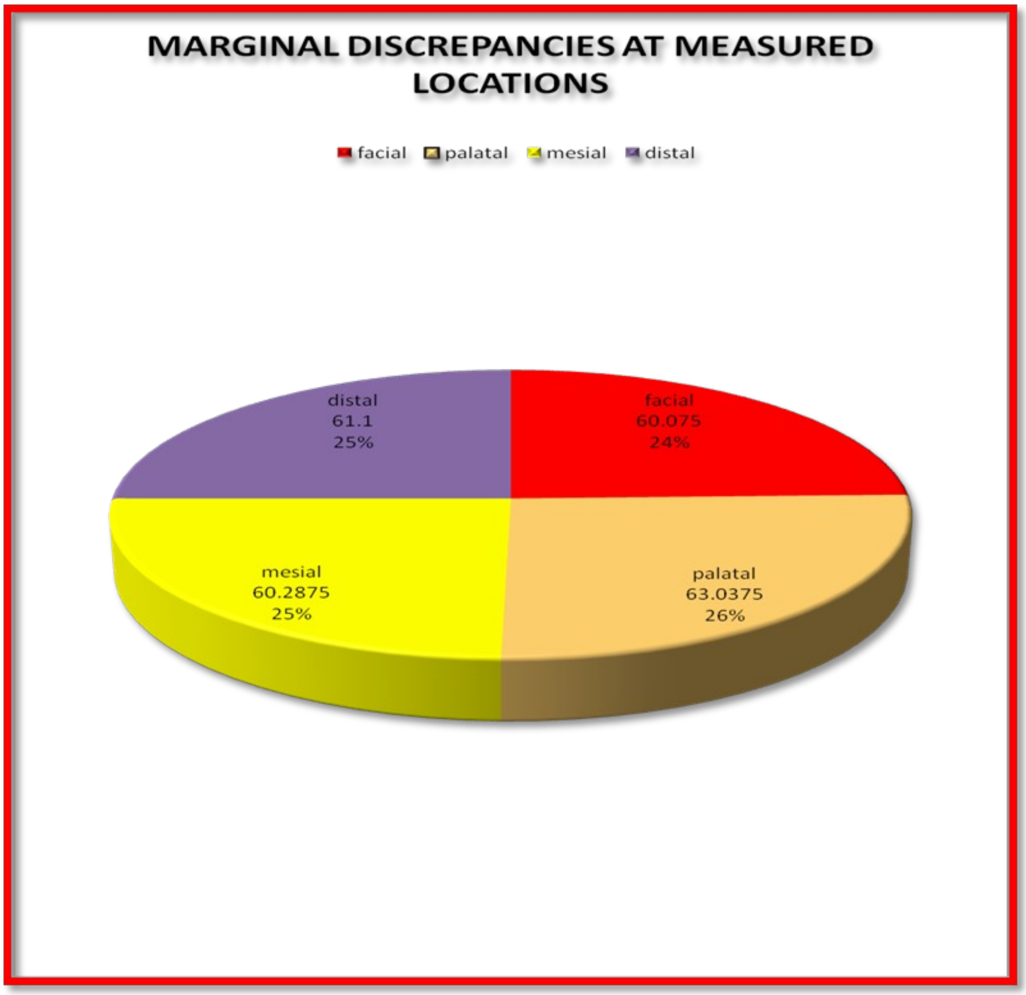
Bar Diagrams






COMPARISION OF MARGINAL FIT OF PRESSED CERAMIC COPING BEFORE & AFTER VENEERING OF PORCELAIN
sub-gr-IIA
sub-gr-II B
67.95
69.45
67.05
68.4
43.6
48.8
44.55
45.7
facial
palatal
mesial
distal


COMPARISION OF THE FINAL MARGINAL FIT OF PRESSED CERAMIC CROWNS & METAL CERAMIC CROWNS
sub-gr-IB
sub-gr-II B
78.75
80.8
78.85
78.9
facial
palatal
mesial
distal


MARGINAL DISCREPANCIES AT MEASURED LOCATIONS
facial palatal mesial distal
distal
61.1
25%
facial
60.075
24%
mesial
60.2875
25%
palatal
63.0375
26%

DISCUSSION

Porcelain jacket crowns have historically been considered the most esthetic restorations. They are made either with or without a metal sub structure. Although the metal ceramic systems have proved to be successful, the increasing demand for esthetic materials in dentistry has resulted in the development of many new metal free ceramic systems with better physical properties.

Ceramic core materials with new chemical composition have been developed, for use with processing methods, combining pressure and high temperature. These are nothing but the heat pressed ceramics which are Leucite-reinforced feldspathic porcelains strengthened by incorporating leucite $K_2OAL_2O_34\ SiO_2$ crystals approximately 45 volume percent , in the glass matrix.[44]

. Heat treatment of Leucite enhances the formation of a highly crystallized microstructure that imparts strength and resists the crack propagation and distortion thus increasing the strength of the ceramic substructure [coping] of the pressed ceramic crown.[61, 34] These core porcelains have also been designed to be compatible for veneering with low fusing porcelains, which provide optical properties necessary for making the most esthetic restorations. Thus a 2 layered all ceramic crown fabricated by heat pressing combines the strength of the core ceramic and the esthetics of the veneering porcelain.

This study analyses the marginal fit of porcelain jacket crowns made with a Leucite reinforced pressable glass ceramic with that of a traditional metal ceramic crown . Moreover this study also analyses the distortion of the coping margins in relation to marginal fit of both the types of crowns induced by the repeated high temperature firing cycles used for veneering of porcelain.

The methodology involved preparation of a typhodont maxillary right central incisor for a porcelain jacket crown. A standardized tooth preparation was done with a uniform shoulder finish line. 20 stone dies were made from individual impressions. This method of making stone dies for study purposes was described by many authors.

Siegbert Witkowski et al 2006 used stone die duplicates of a human maxillary central incisor prepared for a metal ceramic crown, in his study on the marginal fit of titanium copings. James .D. Weaver et al[32] 1991, John .A. Sorensen et al[35] 1992 had also followed the same method of using stone dies of the prepared tooth for their studies on marginal fit evaluation. Shillin burg et al[36] 1973 found that shoulder finish lines with or without a bevel exhibited less marginal distortion in a porcelain fused to metal restoration.This finding was again re inforced by Faucher et al [36] who studied the distortion related to margin design in PFM restorations and concluded that shoulder & shoulder bevel designs exhibit less marginal distortion than chamfer designs. Hence in this study, the tooth preparation was done with a shoulder finish line.

All the metal copings in this study were in a uniform thickness of 0.5 mm. This thickness is as recommended by Strating et al [25]in 1981—who evaluated the marginal accuracy of ceramo metal restorations based on the type of the metal and the coping design. They recommended that the metal copings should have a minimum thickness of at least 0.4 mm to resist the distortion in high temperatures. They also showed that nickel chromium alloys can be cast as accurately as semiprecious or precious ceramo metal alloys.

Silver et al 1960 [58]observed that if the marginal metal was thinned beyond 0.5 mm the porcelain when applied would buckle or bend in thin portions causing a change in fit. This study used nickel chromium alloys to make metal copings in a uniform thickness of 0.5 ± 0.1 mm thickness. The ceramic copings were made in a uniform thickness of 0.7 mm as recommended by the manufacturer.

All the copings were seated on their respective dies and the initial marginal fit was verified by using the video measuring system at a magnification of 100 x. Copings with visibly increased marginal openings or defects in the margins were rejected and new ones were made .The initial marginal fit values were obtained for both the group of copings. This served as the control and was compared with the final values obtained after veneering of porcelain. . This method has been described by Mehmet et al [48] 2005.

The copings were then veneered with their respective veneering porcelains strictly adhering to the manufacturer's instructions and subjected to the firing cycles. Ten metal ceramic and ten pressed ceramic crowns of uniform thickness were made

The final marginal fit of the samples after veneering with porcelain was analyzed by the cross sectional method.

John A.Sorensen et al [35] did a review of all the available methods of measuring the crown margin fidelity and concluded that the cross-sectional method of evaluation of the margins allows greater precision in determination of the measuring points and also in measuring the absolute marginal fit.

They also added that the marginal fit should be measured after cementing the crowns on the test dies. This is because, even in the presense of structurally good margins, complete seating of the crown over the prepared tooth is equally important for obtaining an accurate marginal fit. Increased cement thickness or inadequate space for the cement will prevent the crown from seating completely thus resulting in increased marginal opening. Also, cementation avoids damage to the master die because of repeated usage.

So, in this study the completed crowns were cemented on the dies , mounted in acrylic blocks and then sectioned faciolingually and mesiodistally and the marginal fit was measured at 8 points around the circumference of the crown.

Homes et al [30] in 1989 established measurements of both internal fit & marginal fit and concluded that the best method was to determine the absolute marginal discrepancy by measuring the distance from the margin of the casting to the cavosurface of the tooth preparation. He stated that this distance would always be the largest measurement of error at the margin and reflect the total crown misfit at that point both vertical & horizontal.

In this study also, the measurements of the marginal fit was made from the margin of the casting to the cavosurface of the tooth preparation.

The results of this present study shows that the initial marginal fit of the pressed ceramic copings were better than that of the metal copings.

This is consistent with the findings of M .J Cattell et al [45] in 1999 who reported that the restorations made of pressable ceramic have a good marginal fit He said that it is mainly because of the accuracy of the heat pressing technology. In this system an accurate wax pattern is invested into a refractory mould which is burnt out to allow a ceramic ingot to be pressed into it under high pressure &high temperature. Since the wax fabrication techniques are used in conjunction with this technique it is possible to achieve good marginal adaptation and occlusal relationships with ease[45]. As this technique combines both high pressure and temperature to press the ingot in a viscous state into the mould, it avoids pore formation as seen in the sintering of conventional porcelain and produces a homogenous structure.

Giuseppe Isgro et al [24] in 2003 said that avoiding large pore formation is the major advantage of the hot pressing technique. This method also allows better distribution of the crystalline phase within the glass matrix there by producing restorations of better strength and accuracy.

Mehmet et al [48] 2005 studied the influence of firing cycles on the marginal distortion of 3 ceramic systems and concluded that the multiple high temperature firing cycles during the addition of porcelain to the copings of all ceramic systems caused distortion of the ceramic core resulting in misfit.

Comparison of the results of this study shows that the marginal fit of the pressed ceramic copings had decreased after veneering with porcelain. So it is possible that the repeated firing cycles used for veneering the copings has caused distortion of the core ceramic resulting in increased marginal opening when compared to that of the initial fit.

But the magnitude of distortion is less in pressed ceramics when compared to the metal copings as shown by the results of this study.The reduced distortion of the pressed copings may be because of the following reasons.

The thickness of the core ceramic coping [0.7mm] is more than that of the metal coping [0.5mm]. This is because the metal copings have to be made only at the minimum possible thickness in order to provide enough space to accommodate the veneering porcelain.

Whereas in a pressed ceramic system ,the ceramic ingots which are used to form the core , are available in different shades.So the thickness of the veneering porcelain added to improve the esthetics is less when compared to that of the metal ceramic crowns . Therefore the ceramic copings are subjected to less number of firing cycles than that of the metal copings.

Like wise metal copings are subjected to degassing before application of porcelain. It has been proved by many authors that most of the distortion of the margins occurs during degassing. This step is not needed for the heat pressed ceramics. So, it can be said that the amount of distortion in a pressed ceramic crown is less than the distortion in a metal ceramic crown when both the copings were subjected to multiple high temperature firing cycles.

. According to the literature [21, 25] the factors responsible for the marginal distortion of porcelain fused to metal crown include –

1. Contraction of the veneering porcelain

2. Contamination of the casting that reduces the melting temperature

3. Release of casting induced stresses

4. Type of the alloy used [noble vs base metal alloy]

5. Grain growth of the alloy

6. Progressive reduction in the resilience of the metal because of repeated firing

7. Design of the margin

8. Inadequate support of the metal frame work during firing

9. Thermal contraction mismatch between the metal and the porcelain.

However the common denominator is the repeated exposure to high temperature which definitely causes a misfit of the PFM crowns.

From the results of this study it may be concluded that both the groups of crowns had marginal fit within clinically acceptable levels. But the pressed ceramic crowns had a better marginal fit than the metal ceramic crowns.

The success of the pressable ceramic system is attributed to both the strength of the core material and also the accuracy of the heat pressing technology.

However this study has also got some limitations. The marginal fit of the copings were not measured after each firing cycle. So it was not possible to assess the amount of distortion during the various stages of porcelain veneering. Further longitudinal studies may be helpful to prove the accuracy of Pressable ceramics.

SUMMARY AND CONCLUSION

Recent days the ceramic crowns are the material of choice for esthetic restorations because of their excellent translucency and life like appearance. However just as metal ceramic crowns these crowns also can be distorted during the fabrication procedure especially during the porcelain firing steps thus causing a negative effect on the marginal fit and hence the success of the restorations.

This invitro study was performed to evaluate the accurate marginal fit of the metal ceramic and pressed ceramic jacket crowns over the prepared tooth and also to analyze the distortion of metal and ceramic copings due to repeated firing during the processing procedure.

The test samples were divided into 2 major groups based on the type of copings used for the jacket crown and further divided into 2 subgroups each based on the stage of processing as, before and after veneering of porcelain. So a total number of 20 samples were prepared consisting of 10 samples in one subgroup.

The marginal fit of the samples were measured before and after veneering of porcelain. The results obtained were statistically analyzed.

Within the limitations of the present study and from the results obtained the following conclusions were drawn.

1. The pressed ceramic copings have better initial marginal fit than the metal copings.

2. Both metal copings and pressed ceramic copings show a decrease in the marginal fit after veneering of porcelain. But the amount of distortion in the pressed ceramic copings is less than that observed in the metal copings.

3. The pressed ceramic crowns have a better adaptation than the metal ceramic crowns even after exposure to multiple high temperature firing cycles.

The results of the study show that the pressed ceramic jacket crowns can be reliably used as an alternative to the traditional metal ceramic crowns because of their better marginal fit and superior esthetic value. However further longitudinal studies under conditions simulating the oral environment are needed to prove the success & longevity of the pressable ceramic restorations

APPENDIX

Table 6 . Marginal fit of metal coping before veneering

Sub group IA

No	F-1	P-1	M-1	M-2	D-1	D-2	Mean value
MC1	52	49	51	39	50	48	49
MC2	48	54	49	52	57	42	49.5
MC3	50	54	51	55	56	53	54.5
MC4	53	59	52	48	51	49	50
MC5	48	52	55	50	49	46	47.5
MC6	54	52	56	54	53	51	52
MC7	47	54	48	52	56	51	53.5
MC8	50	53	47	48	53	51	52
MC9	52	54	48	52	53	55	54
MC10	46	50	55	52	51	53	52

Table 7.Marginal fit of metal ceramic crown after porcelain veneering

Sub group IIB

NO	Facial side		Palatal side		Mesial side		Distal side		Mean value
	F-1	F-2	P-1	P-2	M-1	M-2	D-1	D-2	
MC1	73	76	78	81	80	75	75	78	77.000
MC2	79	81	84	82	76	80	78	82	80.250
MC3	76	74	77	74	79	81	83	80	78.000
MC4	79	83	80	82	75	78	74	73	78.000
MC5	81	84	82	85	80	83	79	82	82.000
MC6	80	76	82	84	75	81	79	75	79.000
MC7	78	80	81	85	79	81	80	84	81.000
MC8	74	77	78	76	72	78	75	78	76.000
MC9	77	81	80	76	78	81	77	82	79.000
MC10	82	84	84	85	83	82	80	84	83.000

Table .8 Marginal fit of pressed ceramic coping before veneering with porcelain

Sub group IIA

NO	Facial side	Palatal side	Mesial side		Distal side		Mean value
	F-	P-	M-1	M-2	D-1	D-2	
PC1	40	46	56	38	51	40	45.17
PC2	43	45	47	49	46	48	46.33
PC3	40	48	43	49	38	45	43.83
PC4	43	52	44	40	51	46	46.00
PC5	39	43	41	40	46	44	42.17
PC6	52	54	45	43	46	42	47.00
PC7	51	53	49	38	40	45	46.00
PC8	41	48	43	39	52	48	45.17
PC9	47	54	48	52	43	50	49.00
PC10	40	45	48	39	47	46	44.17

Table 9 .Marginal fit of pressed ceramic crowns after application of porcelain

Sub group IIB

NO	Facial side		Palatal side		Mesial side		Distal side		Mean value
	F-1	F-2	P-1	P-2	M-1	M-2	D-1	D-2	
PC1	67	64	69	67	60	65	71	69	66.50
PC2	71	72	74	73	72	70	73	72	72.13
PC3	66	69	70	64	65	70	68	72	68.00
PC4	68	71	72	69	67	73	68	72	70.00
PC5	66	64	67	65	64	65	66	65	65.25
PC6	66	69	70	68	64	67	65	67	67.00
PC7	64	69	68	71	62	65	63	66	66.00
PC8	71	73	70	72	71	74	71	73	71.88
PC9	62	66	68	66	64	67	63	65	65.13
PC10	68	73	72	74	67	69	67	72	70.25

Surfaces		Metal coping before veneering		Pressed ceramic coping before veneering	
		SUB GR- IA		SUB GR-IIA	
		MEAN of all the 10 samples	S.D	MEAN of all the 10 samples	S.D
FACIAL	F-1	50	2.71	43.6	4.77
	MEAN	50	2.71	43.6	4.77
PALATAL	P-1	53.1	2.73	48.8	4.13
	MEAN	53.1	2.73	48.8	4.13
MESIAL	M-1	51.2	3.26	46.4	4.27
	M-2	50.2	4.54	42.7	5.29
	MEAN	50.7	3.9	44.55	4.78
DISTAL	D-1	52.9	2.73	46	4.67
	D-2	49.9	3.81	45.4	2.95
	MEAN	51.4	3.27	45.7	3.81

Table. 10 .Comparision of initial marginal fit of metal coping with pressed ceramic coping

Table 11 .Comparision of marginal fit of metal coping before and after veneering of porcelain.

SURFACES		SUB GR- IA		SUB GR-IB	
		MEAN	S.D	MEAN	SD
FACIAL	F-1	50	2.71	77.9	2.92
				79.6	3.63
	MEAN	50	2.71	78.75	3.275
PALATAL	P-1	53.1	2.73	80.6	2.46
				81	4.19
	MEAN	53.1	2.73	80.8	3.325
MESIAL	M-1	51.2	3.26	77.7	3.2
	M-2	50.2	4.54	80	2.36
	MEAN	50.7	3.9	78.85	2.78
DISTAL	D-1	52.9	2.73	78	2.79
	D-2	49.9	3.81	79.8	3.74
	MEAN	51.4	3.27	78.9	3.265

Table 12. Comparision of marginal fit of pressed ceramic coping before and after veneering of porcelain.

SURFACESI		SUB GR-IIA		SUB GR-IIB	
		MEAN	S.D	MEAN	S.D
FACIAL	F-1	43.6	4.77	66.9	2.81
				69	3.4
	MEAN	43.6	4.77	67.95	3.105
PALATAL	P-1	48.8	4.13	70	2.16
				68.9	3.48
	MEAN	48.8	4.13	69.45	2.82
MESIAL	M-1	46.4	4.27	65.6	3.75
	M-2	42.7	5.29	68.5	3.27
	MEAN	44.55	4.78	67.05	3.51
DISTAL	D-1	46	4.67	67.5	3.41
	D-2	45.4	2.95	69.3	3.27
	MEAN	45.7	3.81	68.4	3.34

Table 13. Comparisons of final marginal fit of pressed ceramic crowns with metal ceramic crowns

SURFACES		SUB GR-IB		SUB GR-IIB	
		MEAN	SD	MEAN	S.D
FACIAL	F-1	77.9	2.92	66.9	2.81
	F-2	79.6	3.63	69	3.4
	MEAN	78.75	3.275	67.95	3.105
PALATAL	P-1	80.6	2.46	70	2.16
	P-2	81	4.19	68.9	3.48
	MEAN	80.8	3.325	69.45	2.82
MESIAL	M-1	77.7	3.2	65.6	3.75
	M-2	80	2.36	68.5	3.27
	MEAN	78.85	2.78	67.05	3.51
DISTAL	D-1	78	2.79	67.5	3.41
	D-2	79.8	3.74	69.3	3.27
	MEAN	78.9	3.265	68.4	3.34

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